The Effect of Crop Rotation on the Growth and Yield of Rice in the United States [1]

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The cropping system for rice (Oryza sativa L.) in the United States varies with the soil type, drainage and climate. Soil types on which rice is grown include silt loam, clay loam, clay, adobe clay, and fine sandy loam. In most, but not all, rice areas the soil drains sufficiently for the growing of winter crops such as small grains and forage legumes, following rice harvest. The small grain crops sown in the rice areas near the Gulf Coast are used only for pasture or green manure, because the humid climate and accompanying plant diseases preclude profitable grain production. In the Mississippi Valley and Gulf Coast areas, crops are grown without irrigation, but in California, other summer crops are rarely grown on rice lands. In all areas, prices and market outlook are important factors in choosing a crop to rotate with rice.

Satisfactory yields of rice cannot be produced under continuous culture because of the reduction in the amounts and availability of plant nutrients, and because of the accumulation of weeds, grasses and rice diseases. Rotation with other crops also restores the physical condition of the soil.

The Wabash clay (gumbo) and Sharkey clay (buckshot) and similar soils in the Mississippi River Valley are naturally rich in organic matter and mineral nutrients, but are difficult to cultivate except with heavy mechanical equipment. These soils produce high yields of rice and other crops when properly drained. Experiments in Missouri reported by King ( ) demonstrate that crop rotation is essential to high rice yields on Wabash clay soils.

The yields on continuous rice plots declined from an average of 4,428 pounds to 450 pounds in a 6-year period owing to infestation with sedges, grasses "and a variety of other aquatic and semi-aquatic weeds." The yield of rice in the 2-year rice-soybean rotation ranged from 2,907 pounds to 5,944 pounds per acre during the 6 years. Similar rice yields were obtained in four different 4-year rotations that involved other crops such as soybeans (Glycine max Merrill), wheat (Triticum vulgare Vill.), clover and corn (Zea mays L.). Consequently the 2-year rotation was recommended because a greater proportion of the cultivated area could be devoted to rice.

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On Sharkey clay soils in the Mississippi Valley, rice often is grown in rotation with soybeans or lespedeza (Lespedeza striata Hook & Arn) as summer crops or with rough peas (Lathyrus hirsutus) as a winter crop. No well-controlled rice rotation experiments have been conducted on this soil.

On Crowley silt loam soil in Arkansas, the yields of rice declined from 2,232 pounds to 1,506 pounds per acre during 10 years of continuous rice culture, according to Nelson (5). In four 2-year rotations of rice and soybeans, the yields of rice were significantly higher than where rice was grown continuously, particularly where the soybeans were grown in intertilled rows. In other 2-year rotations, lespedeza and soybeans, as alternate crops, increased the yield of rice more than did cowpeas (Vigna sinensis Endl.), cotton (Gossypium hirsutum L.), corn or volunteer vegetation.

Nelson (6) compared the yields of rice following the winter cover crops: hairy vetch (Vicia villosa Roth), crimson clover (Trifolium incarnatum L.), Austrian winter pea (Pisum arvense L.), sweet clover (Melilotus alba Med.), burclover (Medicago hispida Gaertn.), and rye (Secale cereale L.) with no cover crop during a 9-year period. The hairy vetch rotation produced the highest rice yields, averaging 283 to 603 pounds per acre more than no cover crop. Crimson clover and Austrian winter peas plowed under also produced yields significantly higher than the check. Sweetclover and burclover were less beneficial because of limited vegetative growth, but good yields of rice were obtained following burclover that had made satisfactory winter growth. Rice yields following rye were low because of the low nitrogen content of the rye that was plowed under.

The favorable crops, alternating with rice supplied nitrogen, improved the physical condition of the soil, and reduced the competition with weeds and grass, which resulted in higher yields and more uniform stands of rice than in continuous rice culture.

During the first 25 years that rice was produced in Arkansas, the usual practice was to grow rice continuously as long as profitable yields could be obtained and then the field was left idle without cultivation for a year or two before being put back to rice. Rice yields under this system declined about 50 percent, but then remained fairly stable. Cropping systems were then adopted in which rice is grown every third year in rotation with soybeans, lespedeza and fall-sown oats. Typical rotations in Arkansas are: (1) rice followed by 2 years of soybeans or lespedeza, a (2) rice followed by soybeans, followed by fall-sown oats (Avena byzantina . Koch) in which lespedeza is sown for a summer crop following oat harvest In the latter rotation four crops are harvested in 3 years. It is a common practice to apply phosphorus and potassium fertilizers to the other crops in the rotation, and to apply nitrogen as a top dressing to the rice crop.

In a sample survey Slusher ( ) found that 75 percent of the rice farms in Arkansas had supplemental crop or livestock enterprises. The main supplemental crops were oats, lespedeza, soybeans, corn and cotton.

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On Sharkey clay soils in the Mississippi Delta, rice often is grown in rotation with soybeans or lespedeza (Lespedeza striata (Thunb.) Hook & Arn.) as summer crops or with rough peas (Lathyrus hirsutus) as a winter crop. No well-controlled rice rotation experiments have been conducted on this soil.

On Crowley silt loam soil in Arkansas, the yields of rice declined from 2,282 pounds to 1,400 pounds per acre during 10 years of continuous rice culture, according to Nelson (6). In four 2-year rotations of rice and soybeans, the yields of rice were significantly higher than where rice was grown continuously, particularly where the soybeans were grown in inter-tilled rows. In other 2-year rotations, lespedeza and soybeans, as alternate crops, increased the yield of rice more than did cowpeas (Vigna sinensis Endl.), cotton (Gossypium hirsutum L.), corn or volunteer vegetation.

Nelson (6) compared the yields of rice following the winter cover crops: hairy vetch (Vicia villosa Roth), crimson clover (Trifolium incarnatum L.), Austrian winter pea Pisum arvense L., sweet clover (Melilotus alba Desr.), burclover (Medicago hispida Gaertn.), and rye (Secale cereale L.) with no cover crop during a 5-year period. The hairy vetch rotation produced the highest rice yields, averaging 216 to 605 pounds per acre more than no cover crop. Crimson clover and Austrian winter peas plowed under also produced yields significantly higher than the check. Sweetclover and burclover were less beneficial because of limited vegetative growth, but good yields of rice were obtained following burclover that had made satisfactory winter growth. Rice yields following rye were low because of the low nitrogen content of the rye that was plowed under.

The favorable crops alternating with rice supplied nitrogen, improved the physical condition of the soil, and reduced the competition with weeds and grass, which resulted in higher yields and more uniform stands of rice than in continuous rice culture.

During the first 28 years that rice was produced in Arkansas, the usual practice was to grow rice continuously as long as profitable yields could be obtained and then the field was left idle without cultivation for a year or two before being put back to rice. Rice yields under this system declined about 50 percent, but then remained fairly stable. Cropping systems were then adopted in which rice is grown every third year in rotation with soybeans, lespedeza and fall-sown oats. Typical rotations in Arkansas are: (1) rice followed by 2 years of soybeans or lespedeza, and (2) rice followed by soybeans, followed by fall-sown oats (Avena byzantina C. Koch) in which lespedeza is sown for a summer crop following oat harvest. In the latter rotation four crops are harvested in 3 years. It is a common practice to apply phosphorus and potassium fertilizers to the other crops in the rotation, and to apply nitrogen as a top dressing to the rice crop.

In a sample survey Slusher (7) found that 76 percent of the rice farms in Arkansas had supplemental crop or livestock enterprises. The main supplemental crops were oats, lespedeza, soybeans, corn and cotton.

Harvested crops are seldom grown in rotation with rice in the Gulf Coast area of Louisiana and Texas (Jones et al) (2) because the yields of oats, soybeans, cotton, corn and peanuts (Arachis hypogeae L.) are seldom profitable. The most common practice in this area is to grow one or two crops of rice and then to pasture the fields with cattle for one to four years. Formerly, native volunteer grasses were depended upon to furnish forage for grazing. Now the fields are fertilized and seeded with cultivated grasses and legumes which greatly increase the carrying capacity of the pasture and improves the productivity of the soil for rice. Reynolds (8) reports that in Texas annual beef gains of 200 pounds per acre are possible from improved pastures, as compared to less than 50 pounds for unseeded, unfertilized pasture fields. Rice yields were 2,500 to 2,860 pounds per acre following improved pastures compared to about 1,800 pounds following unimproved pasture. Moncrief and Wiehing (4) report that the legumes seeded in improved pastures in rice rotations are white (Trifolium repens L.), Ladino (Trifolium repens L.), red (Trifolium pratense L.), Persian (Trifolium resupinatum L.), subterranean (Trifolium subterraneum L.), crimson, alsike (Trifolium hybridum L.) and Lappa (Trifolium lappaceum L.) clovers, and lespedeza. The clovers most commonly used are white, hop (Trifolium agrarium L.), Persian and red in the more humid east Texas area and annual sweet clover in the drier western area. Grasses seeded are dallas (Paspalum dilatatum Poir.) fescue (Festuca elatior L.) and rye grass Lolium multiflorum Lan. Bermuda grass (Cynodom dactylon L.) usually comes in as a volunteer grass. Walker and Sturgis (12) found in Louisiana that rice following improved pasture produced 1,418 pounds per acre more than when rice followed unimproved pasture. Increases in beef production of from 75 to 214 pounds per acre were obtained by seeding and fertilizing the pastures.

Sturgis (100) found that the yield of rice on deflocculated Crowley silt loam soil was not increased by 600 pounds per acre of 8-8-8 fertilizer until organic matter was added to improve the soil structure. Long continuous culture of irrigated rice changed the character of coastal prairie soils in several respects. The colloids were deflocculated, the reaction of the soil was increased from pH 6.0 to pH 7.1 and large amounts of colloidal iron and silica accumulated. The nitrogen content of the soil was reduced from 0.20 percent to 0.08 percent, soluble and readily available phosphorus from 12.5 p.p.m. to 4.5 p.p.m.; and exchangeable potassium reduced from 100 to 61 p.p.m.

Sturgis and Reed (11) report benefits to the growth and composition of rice on a deflocculated Crowley silt loam soil from treatments including rotation with soybeans and the application of nitrogen, phosphorus, and potash in various combinations. Soybeans alone gave a slight increase, with a marked increase from the further addition of phosphorus. The greatest improvement in rice yields followed the addition of nitrogenous materials in combination with phosphorus and potash. However, virgin soil produced higher rice yields than did any of the treated deflocculated soils. Rice grain produced on the deflocculated soil was lower in nitrogen, phosphorus, sulfur and magnesium and higher in ash, silica, calcium and iron than that produced on virgin soil. Rice grown on treated deflocculated soil was intermediate between that on untreated deflocculated soil and that on virgin soil, in its content of nitrogen, sulphur, calcium and magnesium. Changes in the content of silica, calcium and iron as a result of treatment were rather variable.

Reed and Sturgis (7) reported that the addition of leguminous organic matter was the most effective treatment for improvement of the physical condition of soil deflocculated by long continuous rice culture.

According to Jones, et al, (1) no definite system of crop rotation is followed in California. The heavy soils on which rice is grown and the prevailing high water table during the irrigation season make it difficult to grow any crop profitably in rotation with rice. One system on new land is to summer fallow the field after two or three crops of rice and then sow barley (Hordeum vulgare L.) or wheat in the fall. These grains mature in the spring before the water table is high enough to cause damage. By this system one rice crop is produced in 3 years.

At the Biggs Rice Experiment Station attempts have been made to grow cultivated crops in rotation with rice, but neither corn, grain sorghum (Sorghum vulgare Pers.), cotton or beans (Phaseolus vulgaris L.) produced a profitable crop. Field peas, beans and grain sorghums are sometimes grown in rotation with rice on the higher lands where the water table is lower. These other crops sometimes are grown in overflow areas when the flood waters are not drained off early enough to sow rice.

Some fields that formerly were cropped to rice are seeded to permanent pasture of ladino clover and grasses. These pastures are irrigated and promptly drained at 7-day to 14-day intervals throughout the summer. Much of this land has remained in permanent pasture but good yields are received when such pastures are plowed up and sown to rice. Improved pastures should be plowed in the previous fall or early spring to permit the vegetation to decompose by the time the rice field is submerged.

Purple vetch (Vicia atropurpurea Desf.) one of the most common winter cover crops for rice fields is sown by airplane when the rice field is drained. The vetch makes considerable growth during the mild winter and is plowed under in early spring in preparation for rice. This winter cover crop system favors a maximum acreage of rice on the farm.

All rice in California is sown in the water, and this method usually controls most of the grasses. Chemical such as 2, 4-D can be used to control many of the broad leaf weeds. With the use of nitrogen fertilizer, several profitable crops of rice are obtained before it is necessary to take the field out of production. The common practice is to plow the field in the spring and keep it fallow during the summer. Some growers merely allow the land to lie idle for a year except that it often is pastured. This system partly controls aquatic weeds and releases available mineral nutrients in the soil.

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